RF Control System for the Vertical Superconducting Cavity Test Area at the Spallation Neutron Source

Reset Operation

Write RF Src.,

Clear Graph,

Backup Files

Main VTA Operation

Optimize Phase

Main VTA Operation

Cable Cal.

Read Temp.

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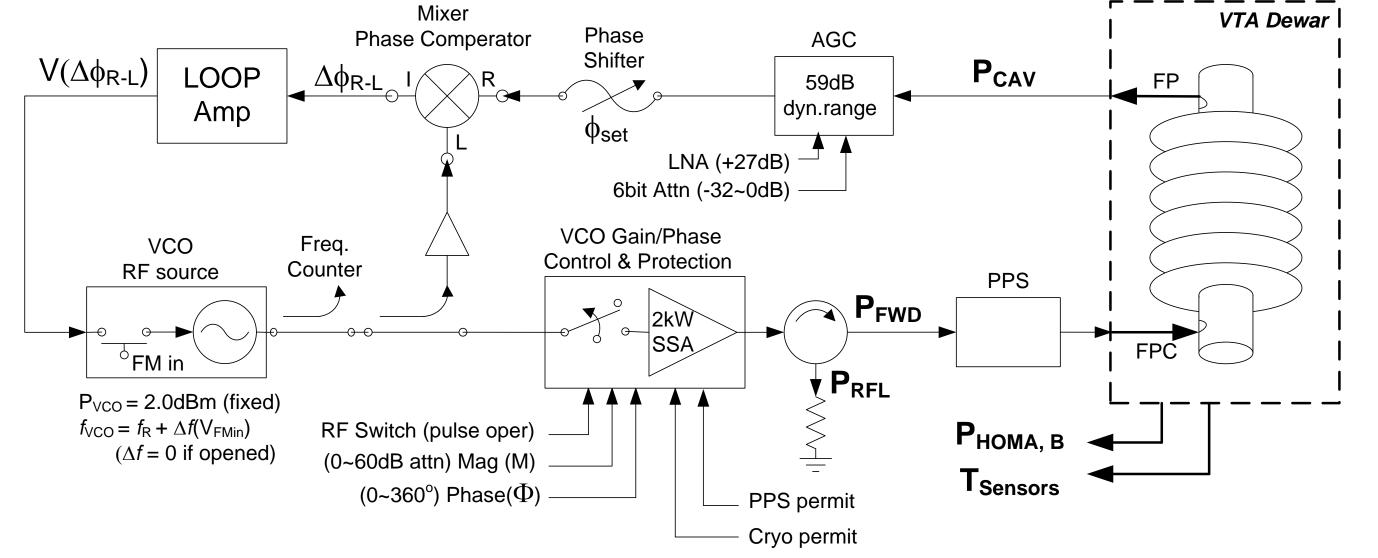
Abstract

A vertical test area (VTA) for testing and qualification of superconducting radio frequency cavities has been built at the Spallation Neutron Source (SNS) Radio Frequency Test Facility (RFTF). This VTA is a part of a larger project to develop in-house capability of prototyping, designing, testing and troubleshooting of the superconducting cavities and cryomodules for the SNS superconducting linac (SCL). The SNS VTA RF control system is a hybrid system consisting of custom built hardware chassis along with commercial test equipment used to qualify SRF cavities prior to installation in a cryomodule. Control and data acquisition is accomplished utilizing LabVIEW software operating on the National Instruments PXIe hardware platform. The system is based on the successful testing programs developed at both Jefferson Lab and Fermilab.

Vertical Test Area (VTA) RF Controls

VTA control system (based on the JLab, Fermilab)

- Self Excited Loop topology
- LabVIEW based system software



Schematic Diagram of SNS VTA RF Control System (Self Excited Loop)

Software – SNS VTA LabVIEW

State machine

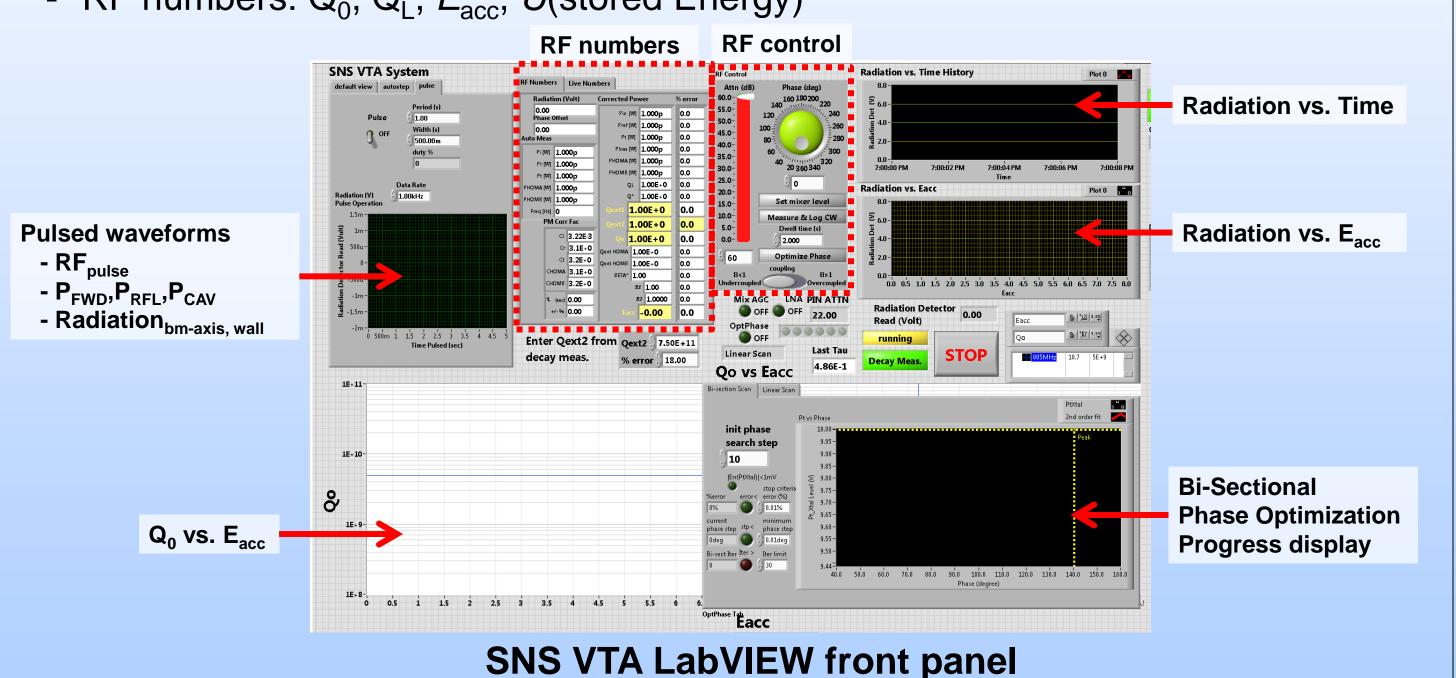
- Initialize: cavity information, tasks
- Cable Cal: power meter offsets
- Reset Operation: RF source, Graph, data file
- Read temperature
- Close/Exit: close tasks, reset initial values, exit

Main VTA Operation

- Set Mixer Level: adjust mixer input level for PLL dynamic range
 - Check Xtal det. voltage (P_{CAV})
 - AGC maintains mixer input level (0dBm)
- Optimize Phase: VCO output phase for peak P_{CAV}
 - Linear Phase Scan method
 - Bi-section Peak Finding method
- Acquire CW/Decay meas.
 - Q_{ext} < 100: Decay measurement (Tau τ)
 - Q_{ext} > 100: CW operation
 - RF number & error calculation
- Auto Step
 - Funct Gen.(RF pulse): coupling C_{β} (over/under?), pulsed wave form display
 - Automatic VCO magnitude step operation, Q₀ vs E_{acc}, Rad vs E_{acc} display

Operation Modes and System Parameters

- Cavity information: f_0 , r/Q, L(cavity length)
- Q_{ext} determines operation mode (CW or Pulse)
- Pulse operation (decay, pulsed waveforms): Tau(τ), coupling factor(C_{β})
- Measurements: P_{FWD} , P_{RFL} , P_{CAV} , $P_{HOMA/B}$, $P_{LOSS} \rightarrow Gamma(\Gamma)$, betas(β 's)
- RF numbers: Q_0 , Q_L , E_{acc} , U(stored Energy)



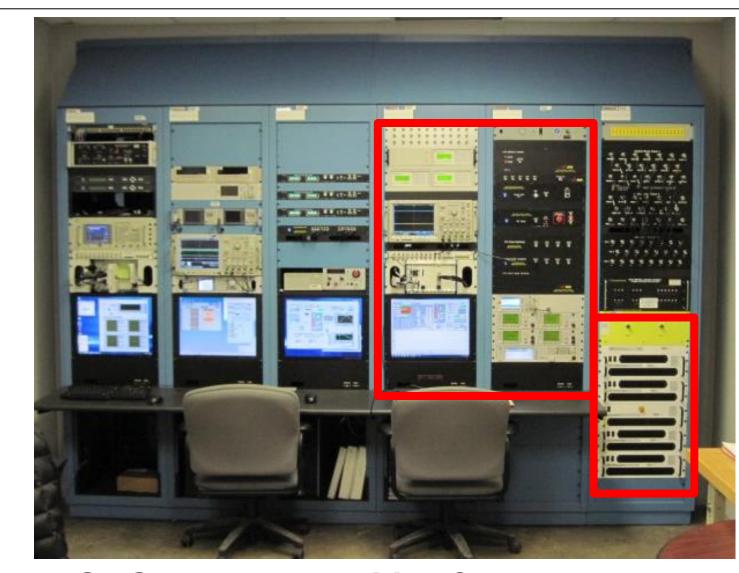
Hardware – RF Control, DAQ

SNS Designed Equipment

- VCO/RF Drive Chassis
- Cavity Input PLL Chassis
- Power Monitoring Chassis
- Signal Conditioning Chassis
- Signal Distribution Chassis

2kW Solid State Amplifier (SSA)

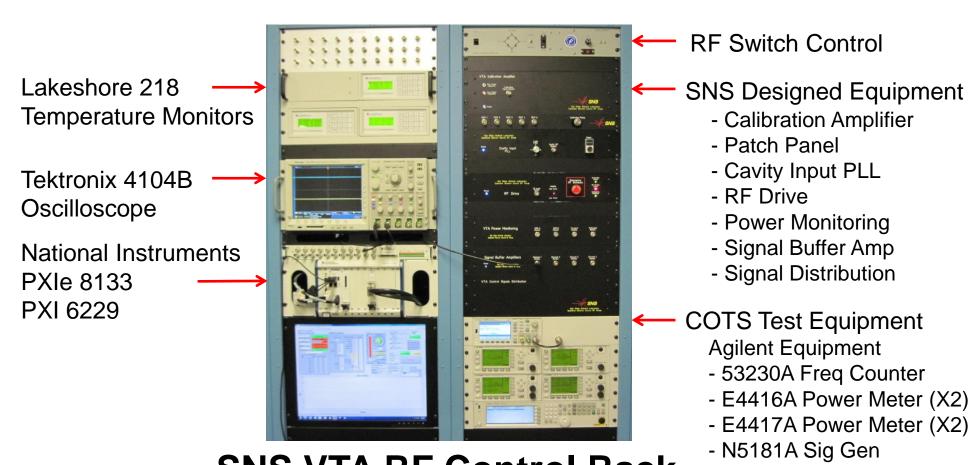
- Tomco 2kW amplifier (4-500W amplifier blocks)
- Combiner w/local shutdown
- RF High power switch (VTA or SNS Test cave)



SNS RF Test Facility Control Room

Commercial off the shelf (COTS) Test Equipment

- Agilent 53230A Frequency Counter
- Agilent E4416A(x2) E4417A(x2) Power Meters
- Agilent N5181A Signal Generator
- Lakeshore LS218 Temperature Monitors(x3)



SNS VTA RF Control Rack



2kW Tomco SSA

Hardware – Interconnection

Dewar RF Cables/ PPS

- RF drive(P_{FWD}, P_{RFL}), Field Probe(P_{CAV}), HOMA & B
- RF Drive Cable is PPS controlled

Temp. Sensors

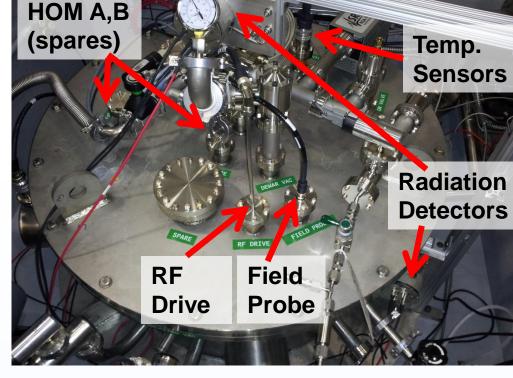
8 Cernox sensors installed

Radiation Detectors

- Support for 16 additional sensors



VTA patch panel



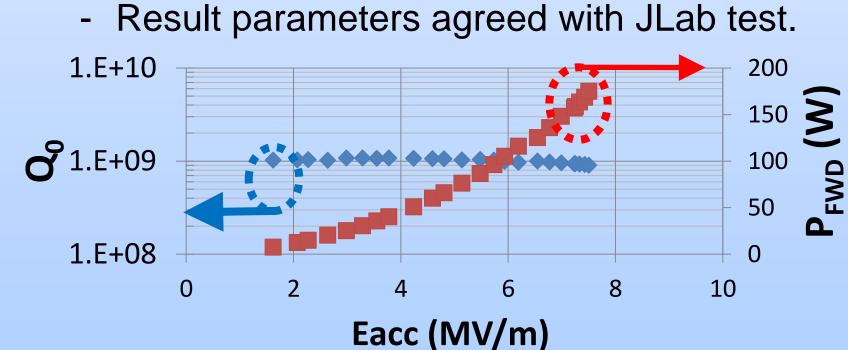
Dewar Cable Connection

SNS VTA Commissioning

- 2 PMTs installed Beam axis, wall

Initial Test of Cavity at 4K (LHe)

- SNS high-β (0.81) 6-cell superconducting cavity
 - Pre-tested at Jefferson Lab
- Frequency: 804.572200MHz
 - Bandwidth: ~1Hz
 - Freq. deviation by He pressure: ~ +/-10kHz
- PLL system locked
 - CW mode operation
 - Manual mixer input level, phase adjust control
- System Verification
 - Cable calibration and hardware impacts.







Radiation shield at dewar area P_{RFL} X'tal Detector P_{FWD} (FPC)

Scope signals PLL system locked

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